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EFFECTS OF COMMUNITY-WIDE INSTALLATION OF HOUSEHOLD GARBAGE-GRINDERS ON ENVIRONMENTAL SANITATION

George K. Erganian, et al

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... effects of community-wide installation of household garbage-grinders on environmental sanitation

by
GEORGE K. ERGANIAN
WALTER G. BELTER
Sanitary Engineers,
Indiana State Board of Health
RALPH C. GRABER
Senior Sanitary Engineer,
U. S. Public Health Service

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introduction

Jasper, Indiana, a community of 5,215 persons, embarked on a project to eliminate the garbage can through the use of household garbage-grinders in December 1949. As the first municipality in the United States to attempt the city-wide installation of household grinders, Jasper presented an excellent opportunity to study the effects of these installations on the environmental sanitation of the community. Recognizing this opportunity, the Public Health Service and the Indiana State Board of Health set forth to make a comprehensive study at Jasper.

A preliminary report of this investigation, covering the period of March 1950 to October 1951, is presented here. Since there is need for more data in some phases of the study before additional conclusions can be drawn, it is proposed to continue the study until such observations can be made. As none of the commercial food-handling establishments in Jasper has as yet installed garbage-grinders, the effect of such units on the sanitation ratings of these places could not be determined. "Before" ratings of establishments have been made, however, and the matter will be considered further in the event that grinders are installed.

The City of Jasper

The City of Jasper, the county seat of Dubois County, is situated in the southwest section of Indiana, approximately 120 miles southwest of Indianapolis. The surrounding rural area is dependent upon the city for shopping and marketing facilities, and for cultural and social activities. The city is on the Patoka River, which flows west for 86 miles, discharging into the Wabash River at a point 96 miles from its confluence with the Ohio River.

Jasper is a major desk-manufacturing center, with 18 manufacturing concerns dealing in wood or wood products, which represent about 90 percent of the total number of industrial establishments in the city. Most of the factories are owned by Jasper residents, and over 92 percent of the homes in Jasper are owned by their occupants. The city is generally clean and neat, with only a few substandard homes. The water, power, and light facilities are municipally owned.

Development of Project

Pollution of Patoka River.—Because the City of Jasper was contributing to the pollution of the Patoka River, a preliminary order to abate this pollution was issued by the Stream Pollution Control Board of Indiana on August 31, 1945. A final order of the Board became effective on December 14, 1945. In compliance with this order, the City engaged an engineering firm in 1946 to make a study of its need for additional sewers and sewage-treatment facilities. The preliminary report proposed a 1,000,000-gallon-per-day activated-sludge plant, with the necessary intercepting sewers. Certain additional trunk, relief, and lateral sewers were also recommended, to relieve overloaded conditions in sections of the existing sewer system, and to provide additional sewer service. Plans and specifications for the sewage-treatment plant and intercepting sewers were approved by the Stream Pollution Control Board and State Board of Health on September 14, 1948.

Investigation of other methods of garbage disposal.—While the sewerage project was under active consideration, an outbreak of hog cholera occurred among garbage-fed hogs in the vicinity of Jasper, as a result of which the City soon had difficulty in finding contractors to handle its garbage. Faced with this situation, the

City investigated three other methods of disposal: (1) individual home grinders; (2) central grinding; and (3) sanitary landfill. The City administration became convinced that the individual household grinder was a feasible method of disposal, because it eliminated the garbage can, and promised certain other public-health benefits.

Accordingly, revisions were made to the plans for the sewage-treatment plant, in order to accommodate the anticipated increase in load due to garbage. The revised plans were approved in March 1949. In the meantime, a vigorous promotional campaign to obtain public acceptance of the home grinder had been conducted by the City administration and by civic organizations. Newspaper articles, public demonstrations of the unit, talks before civic groups and business organizations, and house-to-house canvassing were used to gain the support of local citizens.

Local and State legislation.—To further the project, it was necessary for the City to obtain legal authority to purchase and install units on a city-wide basis. A bill to this effect was enacted by the State Legislature on March 7, 1949 (Chapter 87, Acts of 1949), permitting the issuance of revenue bonds for the purpose of installing household garbage-grinders, and providing the municipality with authority to establish such a project. The important features of the Act are:

(a) Every city or town shall have power to acquire, install, own, operate and maintain a garbage-disposal system consisting of garbage-grinders to be installed in private residences, business places, and other buildings, provided that the municipality owns and operates, or has under construction, a sewage-treatment works, and that the consent of the owners and tenants has been obtained.

(b) Revenue bonds may be issued to meet the cost of grinder installations in the same manner that such bonds are issued to finance municipal water- and sewage-works construction.

(c) Service charges may be levied against grinder users in the same manner as for water or other utilities.

The City passed an ordinance allowing each home to dispose of its garbage in any manner deemed satisfactory to the City Board of Health or its Health Officer; forbidding garbage to be deposited outside of residences, except that which is to be removed to disposal points designated by the City; and requiring any person desiring to collect or transport garbage on a commercial basis in the city to obtain a permit, which will be granted only after the collection vehicle and method of disposal have been approved by the City Health Officer.

Purchasing arrangements.—Bids for the supply and installation of garbage-grinders were received by the City. The units were

required to meet certain physical and performance specifications, and were to be installed under the supervision of the successful bidder in accordance with the local and State plumbing and electrical codes. Although the enabling Act has provisions for revenue-bond financing, the citizens of Jasper decided that financing without the use of revenue bonds was more desirable.

To assure success of the project, it was decided that, before going ahead, at least 50 percent of the home owners would have to file applications with the City signifying their intent to install household grinders. A deposit was required with each application, with the balance to be paid immediately prior to installation. All money so obtained was placed in a trust fund, from which the cost of installation of the units was paid as the work progressed. In this way, the City incurred no financial obligation.

Determination of potential users.—In March 1950, it was determined that approximately 1,300 families were possible users of household units. Of this total, 33 families indicated a desire to share a unit with another family; 53 families, with negligible amounts of garbage, were not considered to be possible users. Therefore, over 1,200 families were potential purchasers of household units, including 80 who already had garbage-grinders installed.

Installation problems.—About 60 percent of the sink openings were too small, and others were too large. A special grinding tool was developed to enlarge small openings, and adapters were made for the large ones. A press was designed to enlarge and crimp the openings in steel sinks, and a special trap was perfected for difficult plumbing installations.

Four plumbing and two electrical concerns contracted to do the actual work of installation, under the supervision of a manufacturer's representative. A 1-year maintenance warranty was provided with each unit.

TABLE 1.—*Progress of grinder installations*

Period	Number of installations during period	Cumulative total
Previously installed		80
Mar. 15–31, 1950	20	100
Apr. 1–Apr. 20	127	227
Apr. 21–May 26	217	444
May 27–June 30	104	548
July 1–July 28	166	714
July 29–Aug. 4[1]	18	732
Aug. 5–Sept. 15	39	771
Sept. 16–Oct. 23	14	785
Oct. 24–Dec. 31, 1950	20	805
Jan. 1–Feb. 28, 1951	25	830
Mar. 1–Sept. 30	54	884
Oct. 1–Dec. 28, 1951	18	902

[1] Garbage collection ceased Aug. 1, 1950.

Installation progress.—Unit installations began during the last week of March 1950. Approximately 35 grinders were placed in operation each week through the first week in August, when municipal garbage collection ceased. At that time, a total of 730 grinders had been installed, including previous installations. A monthly summary of grinder installations is presented in table 1. There are now over 900 units in operation. The total number of persons served by household garbage-grinders represents approximately 75 percent of the population of Jasper.

Scope of Investigations

It was decided that, in pursuing this study, the investigations should be broken down into two major categories: (1) the study of those municipal services, such as water supply, sewers, sewage treatment, and refuse collection, which might be affected by the mass installation of garbage-grinders; and (2) the study of those measures of environmental sanitation, such as fly and rodent populations, and morbidity and mortality records, which might be considered indices of the actual health benefits derived from this method of garbage disposal.

Results of Investigations

Water Consumption

The water supply for the city of Jasper is municipally owned and operated. The water is obtained from the Patoka River, and is treated by aeration, coagulation, sedimentation, rapid sand filtration, and chlorination.

Procedure.—Information was obtained concerning water consumption over a period of six years prior to the installation of household units and for the period during and after the installations. The Water Department's records were studied, and the monthly residential, commercial, industrial, and rural consumption separately recorded.

Presentation of data.—For the purpose of comparing water consumption before and after the installation of grinders, the 3-month period, January to April 1950 (prior to the installation of grinders), and the 3-month period, January to April 1951 (after the majority of grinders had been installed) are shown in table 2. It should be noted that a sewer-service charge was initiated during the period in which grinders were being installed, which may have caused conservation in the use of water, due to an impression that the water bills would be "doubled."

TABLE 2.—*Effect of garbage-grinder installations on water consumption*

Period	Number of residential connections	Population served	Average number of grinders in operation (approx.)	Residential connections with grinders (percent)	Residential water consumption (MGD)	Per capita water consumption [2] (gal./cap./day)
1950						
January	[1] 1,202	5,192	78	6.5	0.157	30.2
February	[1] 1,203	5,196	78	6.5	.143	27.6
March	1,204	5,200	80	6.6	.125	24.0
Average						27.3
1951						
January	1,233	5,327	803	65.0	0.147	27.6
February	1,235	5,336	820	66.5	.165	31.0
March	1,237	5,344	835	67.5	.121	22.6
Average						27.1

[1] Estimated.
[2] Based on residential water usage only.

Analysis of data.—From the comparison of the two periods shown in table 2, it appears that there has been no noticeable change in the rate of water usage by residential consumers, despite the substantial increase in the number of household garbage-grinders.

Additional information will permit a more accurate comparison, based on a 1-year period without grinders as against a 1-year period with grinders.

Sewerage System

Jasper is served by both sanitary- and storm-sewer systems. The original sanitary system was constructed in 1910, with the first area assessments for sewers being made in 1911. Considerable portions of the north and northeastern sections of the city were sewered in 1925-30, with additions in 1938-39. Additional sewer improvements were completed in 1950-51. The sanitary system is comprised mostly of 8-inch and 10-inch sewers, with several short, 6-inch laterals. Prior to the construction of the sewage-treatment plant, the main outfall to the Patoka River was a 12-inch sewer. A lift station was used to pump sewage into the river during periods of high water. A new, 21-inch sewer now intercepts the former outfall, the flow being diverted to the treatment plant.

Procedure.—Seven manholes, representing various sections of the sanitary-sewer system, were selected for study. The grade and size of each sewer leading from, or discharging to, these manholes were obtained. From time to time, information concerning the location of the grinder installations was related to these selected sewers. The presence or absence of deposits in the sewers was noted, by observation and by photographs. Laboratory analyses for total solids and total volatile solids were made of all sludge found.

TABLE 3.—*Observation of selected sanitary sewers*

Sewer designation	Size	Slope	Velocity[1]	Visual observations												
				April 18, 1950					October 2, 1950			June 27, 1951				
				No. of		Flow depth (inches)	Sludge depth (inches)	Remarks	Flow depth (inches)	Sludge depth (inches)	Remarks	No. of		Flow depth (inches)	Sludge depth (inches)	Remarks
	(inches)	percent	ft/sec	Grinders	Sewer conn.							Grinders	Sewer conn.			
I-A	8	0.46	2.2	6	37	½	¼	Sewage milky	½	None	Slight scum	30	37	¾	½	Dirt and roots in opening.
I-B	6	7.25	6.8	3	15	(2)	½	Sewage clear	¼	None	Sewage milky	16	15	¼	None	Black slime on bottom.
I-C	8	1.45	2.2	3	22	(2)	None	Sewage milky	(2)	None		14	22	½	None	Sewage milky.
II-A	8	3.22	5.75	3	16	½	⅜		1	None		10	16	1½	None	
II-B	8	.....	.....	1	2	¼	None		(2)	None	Grayish scum on sides	2	2	½	None	Slight slime on bottom.
II-C	8	1.11	4.0	2	14	½	¼	Sludge on sides–none on bottom	1	None	.....do.....	8	14	1½	½	Garbage solids in suspension.
III-A	10	.....	.....	47	138	⅜	None	Slime on sides	1	None	Grit deposits on sides	91	145	2½	None	Traces of grit.[3]
III-B	8	.....	.....	7	39	½	¼	.....do.....	½	¼	Black deposits	30	45	1	½	Black slime on bottom.[3]
III-C	8	.61	2.5	40	99	½	¼	.....	1	None	.....	61	100	1½	None	White slime on bottom.[3]
IV-A	10	.23	1.8	29	259	¾	None	Little slime	1½	None	.....	187	267	4	¾–1	Black septic solids.[4]
IV-B	8	.68	2.6	2	21	(2)	¼	.....	½	None	.....	19	21	1½	None	Black slime on bottom.[4]
IV-C	8	3.25	5.7	3	21	¼	½	Slime on sides	(2)	None	.....	12	21	(2)	None	Muddy.[4]
IV-D	10	1.09	3.9	24	217	¾	½	Clean on sides	1	None	.....	156	225	1½	½	White scum.[4]
V-A	10	.....	.....	85	468	8	1	Grit and rags	5	2–3	.....	317	488	8	1½	Coarse solids.
V-B	10	0.58	2.8	85	468	5	2	.....	7½	.....	Septic odors	317	484	7	3	Coarse, gritty solids.
V-C	8	.28	1.75	.....	.....	6½	1½–2	.....	4	None	.....	.....	4	8	1	Pipe submerged.
VI-A	8	1.57	3.9	5	80	2	¼	.....	(2)	1	Paper 1" in depth	56	80	1½	.....	Paper clogging.
VI-B	8	35	1.9	4	77	1¾	¼	.....		None	Sewage stagnant	52	77	2½	None	Paper settled out.
VI-C	8	1.81	4.2	1	3	(2)	None	.....		None	.....	4	8	2	½	Blocked by clump of solids.
VII-A	12	.....	.....	.....	.....	5½	None	—DISCONTINUED Sewer sealed—sewage now to 21" sewer								

VII–B.....	10	.....	.....	17	219	2½	½	Septic odor	7	¾	Deposits showed garbage solids	144	210	6	4	Black, coarse solids.
VII–C.....	12	.16	1.75	124	885	3½	¼	.....	8	None	.....	640	922	7	None	Good velocity.

[1]Theoretical velocity when flowing full or half full.
[2]Trickle.
[3]Clean manhole—ample velocities.
[4]Septic odor—black solids deposited on entire floor of manhole.

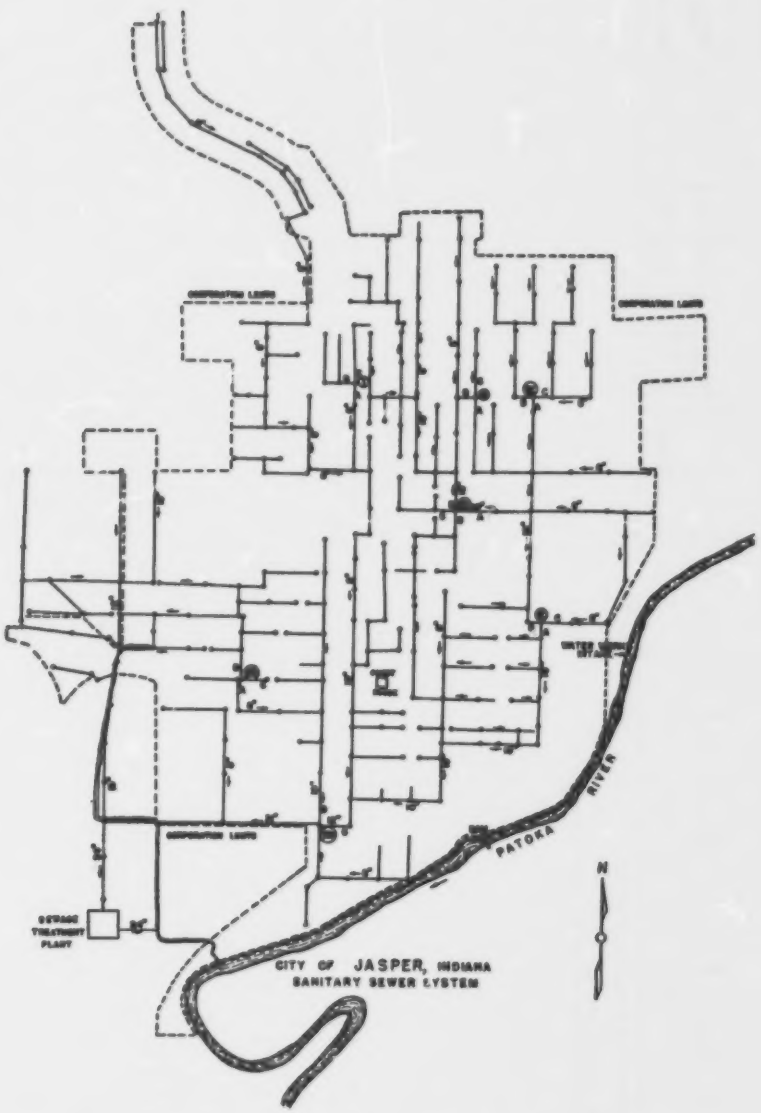

FIGURE 1.—*Jasper Sewer System and Location of Study Manholes.*

Presentation of data.—Figure 1 shows the location of manholes selected for study. The sewers leading to, and discharging from, the manholes were found to range in grade from 0.16 percent for the 12-inch trunk sewer, to 7.25 percent for a 6-inch lateral (theoretical velocities of 1.75 ft/sec. to 6.8 ft/sec.). Table 3 presents summary data based on observation of the sewers, correlating the number of grinders served by each. Sewers are identified by Roman numerals and letters, the Roman numerals referring to the manhole to or from which the sewers lead. The sewers identified by the letter "A" after the numeral are out-going; all others are incoming.

Analysis of data.—With the exception of one group of sewers leading to, and discharging from, manhole V, and 6-inch sewer I-B, the sewers under investigation were reported normally to require no maintenance. In all, 22 different sewers were inspected, on 16 of which grades were obtained. One of the sewers originally inspected has now been abandoned and, of course, will not be considered further.

In general, there did not appear to be any deleterious effect on the sewers under observation, as the result of the introduction of ground garbage. On the contrary, of the 16 sewers which were noted, in April 1950, to have sludge deposits, 13 had either equal or lesser amounts of sludge in June 1951. Five sewers showed increased deposits of sludge; these were sewers IV-A, V-A, V-B, VI-C and VII-B. In each case, upon investigation, it was determined that other factors not connected with the introduction of ground garbage were likely to have been the contributing cause.

In April 1950, sewer IV-A was clean except for a small amount of slime, and in October 1950 a similar condition was observed. However, in June 1951, a ¾-inch to 1-inch deposit of black septic sludge was observed. Depth of flow in this sewer was much greater than in either of the two previous periods. Analysis of the sludge revealed an increase of almost 500 percent in total solids.

The grade of sewer IV–A is 0.23 percent, providing a velocity of only 1.8 ft/sec. when flowing full, or a capacity of 0.6 MGD; while the combined capacity of the three incoming sewers is 3.3 MGD. From the appearance of manhole IV, which indicated flooding, it was obvious that sewer IV–A is incapable of handling the entire flow from the incoming sewers during wet-weather periods. As a result, the sewage flow in incoming sewers is undoubtedly retarded, and it is reasonable to believe that an abnormal amount of solids remains in these incoming sewers until such time as the surcharged condition in manhole IV subsides. These solids, upon entering sewer IV–A with its flat grade, would have a tendency to settle out. The solids stranded in the manhole are also considerable, and are carried away gradually with the

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sewage flow. This could have a definite bearing on the situation observed, since rain had fallen on the day before the June 1951 survey.

There are three sewers discharging to, or leading from, manhole V, which receives the discharge from almost one-half of the city plus a considerable portion of the industry. While it was impossible to obtain grades on sewer V–A (the sewer leaving the manhole), it was learned that this sewer was laid on an extremely flat grade, and that the manhole stands full for considerable periods of time, and is subject to frequent overflowing. (These conditions were verified by observation.) Sludge observed in manhole V in April 1950 was probably silt and mud deposits, as suggested by its low volatile-solids content. During the succeeding surveys, it was observed that the quantity of sludge increased in both sewers V–A and V–B. A significant sludge deposit remained in sewer V–C. In all three sewers, the volatile content of the sludge was found to be increasing. This may be attributed to the fact that the number of garbage-grinders contributing to these sewers quadrupled between April 1950 and June 1951. It is felt that whatever deposits occurred can be attributed to the hydraulic inadequacies of these sewers.

Sewer VI–C, which was clean during the April and October investigations, showed a ⅛-inch sludge deposit in June. A heavy, gelatinous mass of solids was discovered blocking the entrance of sewer VI–C into the manhole. This caused the sewage to back up a considerable distance in the sewer, and undoubtedly caused the sludge deposit observed. Garbage solids were not identifiable, and the analysis of the solids revealed a volatile content of only 26 percent.

In April 1950, there was a slight deposit of sludge in sewer VII–B. In October, an increase in sludge deposits, accompanied by noticeable garbage solids in suspension, was observed. Four inches of sludge, a substantial increase over the previous surveys, were noted in June; however, large amounts of cinders, small stones, and gritty material were observed on this occasion.

Manhole VII empties directly into the 21-inch intercepting sewer (see figure 1). Approximately seven-eighths of the city's entire sewage flow must pass through it. From two-thirds to three-quarters of the flow passes through VII–C (12-inch) from the east, and the remainder flows from the north through VII–B (10-inch). At the time of the April 1950 survey, the outfall sewer to the Patoka River ran south from manhole VII. The old outfall is now sealed off, and the sewer connecting manhole VII to the 21-inch interceptor is located in the northwest section of the manhole. Thus, the heavy flow from VII–C must pass directly in front of VII–B in order to reach the interceptor. Visual observations

showed that the flow in VII–B was being seriously retarded by flow from VII–C. Again, hydraulic factors appeared to be more responsible for sludge deposits than the presence of ground garbage.

Raw-Sewage Characteristics

Procedure.—Twenty-four-hour composite samples were collected on eight days during March 1950, and were analyzed in the laboratories of the Indiana State Board of Health. Laboratory examinations were started at the sewage-treatment plant in July 1950. Fourteen 24-hour composite samples were collected during August 1950. During the months of October 1950 and May 1951, continuous 2-week, 24-hour, sampling surveys were undertaken, and the samples were analyzed. Additional analyses were made of samples collected at hourly intervals, in order to determine hourly variations in the load. Flow data were also recorded at the time of these sampling surveys. A temporary V-notch weir, head recorder, and Trebler sampler were installed at the main sewer outfall to the Patoka River during the period of the March 1950 survey. When the sewage plant was completed in late June, a weir, head recorder and the Trebler sampler were relocated at the plant. Through August 1950, the Trebler sampler and portable head recorder were used to obtain raw-sewage samples and flow data. During the October survey, the use of the Trebler sampler was abandoned, and all samples were collected by hand. Samples collected by the Trebler sampler were obtained every 45 minutes. Hand samples were collected hourly.

Presentation of data.—Data collected during the March 21–25 and May 20–June 2 periods were considered representative of wet-weather flow. Typical dry-weather flows were observed in the other three periods.

Samples collected during the May 20–June 2 period included industrial wastes from a newly-constructed poultry-packing plant, which processed 316,000 pounds of chicken and 17,000 pounds of turkey during that 2-week survey. Three 24-hour surveys of plant wastes were made. The average concentrations of poultry waste discharged, based on the results of these sampling surveys, are presented in table 4.

TABLE 4.—*Estimated load from poultry-packing plant*

Per 1,000 lbs. poultry, live weight

	Pounds
Biochemical oxygen demand	5.18
Total solids	8.4
Total volatile solids	6.1
Suspended solids	2.3
Suspended volatile solids	2.1
Grease (ether soluble)	0.7

The results of three surveys showed considerable variations. For example, B.O.D. values, based on lb. B.O.D./1,000 lb. live weight, ranged from 2.78 to 7.7. The averages, however, have been used for the purpose of this preliminary report. Additional data will be necessary to permit establishing a more reliable parameter by which to gauge the poultry-waste load.

Tables 16 and 17, in the Appendix, present chronological information on the changes in raw-sewage composition over the period in which garbage-grinders were installed, and data relative to the hourly variation in raw-sewage characteristics.

Analysis of data.—Upon comparing the data presented in table 5, it will be noted that there is considerable variation between results for wet-weather and dry-weather periods. (Flows averaging 0.4 MGD or more have been considered representative for periods of wet-weather. Flows of about 0.4 to 0.6 MGD, occurring over extended periods of time, were believed due to high groundwater conditions and infiltration.)

While dry-weather data should furnish the more reliable information, the collection of wet-weather data during periods of comparable flow was believed to be also of some significance. The higher organic loadings during wet-weather periods, both before and after the garbage-grinder installations, were possibly due to flushing of deposits in sewers; this was indicated by visual observations.

TABLE 5.—*Sewage characteristics—per capita basis*

Period of survey	During dry weather			During wet weather	
	Mar. 8–11, 1950	August (14 days) 1950	Oct. 9–21, 1950	Mar. 21–25, 1950	May 20–June 2, 1951 (see note)
Total no. of grinders	80	752	785	100	873
Pound B.O.D. per cap/day	0.12	0.20	0.18	0.18	0.31
Pound T.S. per cap/day	.39	.....	.41	.54	.88
Pound T.V.S. per cap/day	.18	.....	.26	.25	.59
Pound S.S. per cap/day	.19	.21	.20	.18	.34
Pound V.S. per cap/day	.14	.....	.16	.16	.29
Pound grease per cap/day	.....	.....	.07	.07	.16

Note.—Does not include poultry-packing-plant waste; plant was placed in operation in January 1951.

On the basis of the data presented above, it can be said that there is an increase in the concentration of solids and organic material in sewage which is receiving quantities of ground garbage. It should be carefully noted that the information does not attempt to assign any value to the per capita contribution of ground garbage; the relatively sparse data compiled, together with the many variables which affect sewage and garbage quantities from day to day and from month to month, make it impossible to do so with any reasonable degree of accuracy at this time. Utilizing the data in table 5, and by mathematical computation,

it is observed that, on the basis of the information compiled to date, the B.O.D. contributed per capita by garbage alone has varied from 65 to 100 percent of the sewage load. Suspended solids have varied from zero to 100 percent. Suspended volatile solids have ranged from 20 to 90 percent of suspended volatile solids in sewage.

The effect of garbage-grinder installations on the variation in sewage characteristics during each day is shown graphically in figure 2. For comparison purposes, all values have been converted to a percentage basis. For each day in which hourly or bi-hourly samples were collected and analyzed, the 24-hour average load in pounds of biochemical oxygen demand, total solids, total volatile solids, suspended solids, suspended volatile solids, and grease was determined. Hourly rates of loading were then compared to this average daily load to obtain the percentage figures for hourly variations in load.

From figure 2, it may be observed that there is relatively good correlation in the hourly variation in B.O.D. loadings over the five 24-hour periods, despite the fact that these periods represent a wide variation in the number of grinders in operation. In studying this graph, it should be observed that the curve for March 8, 1950, representing a period prior to the mass installation of grinders, is based on data collected on Wednesday. Presumably, if this had been a Monday survey, the peaks might have been more pronounced, particularly for the midmorning period.

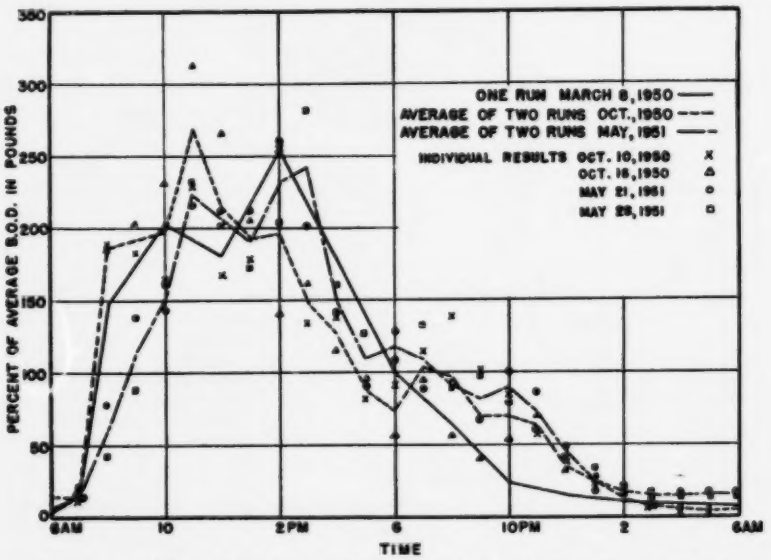

FIGURE 2.—*Effect of Garbage on Hourly Variations in Raw-Sewage B.O.D.*

With the exception of a 2-hour period on Monday, October 16, 1950 (between 10:30 a. m. and 12:30 p. m.), and for a 1-hour period during May 28, 1951 (2:30 p. m. to 3:30 p. m.), there appeared to be no difference in peak B.O.D. loadings. The most pro-

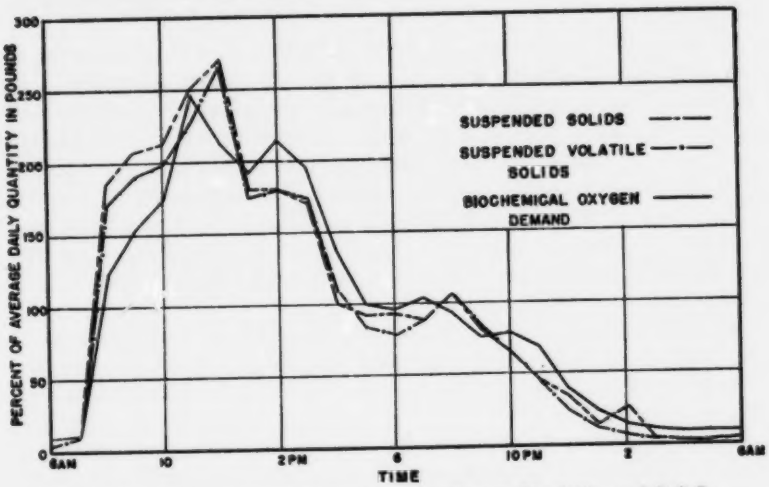

FIGURE 3.—*Comparison between Average Hourly Variations of B.O.D., Suspended Solids, and Suspended Volatile Solids.*

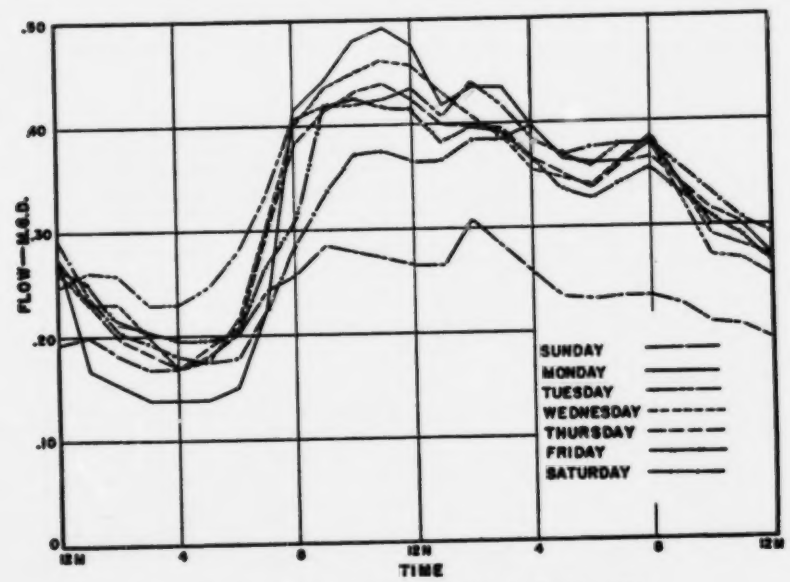

FIGURE 4.—*Average Hourly Variations in Sewage Flow.*

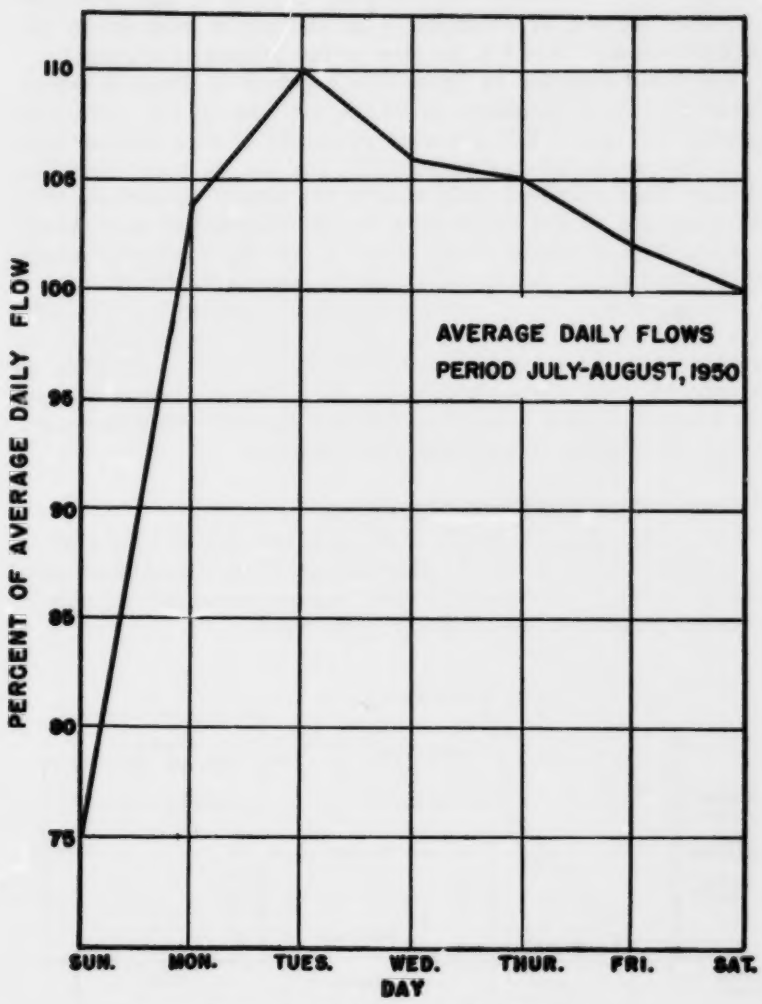

FIGURE 5.—*Variation in Daily Flow.*

nounced peak (312 percent of average, observed on Monday, October 16, at 11 a. m.) did not recur on either of the two Mondays on which similar tests were made in May 1951. In general, peak B.O.D. loads were observed between 10 a. m. and 12 noon (200-260 percent of average), again about 2 p. m. in the afternoon (200-260 percent of average), with the minor peak being observed between 7 and 9 p. m. (100 to 120 percent of average).

The trend observed in figure 2 is repeated in figure 3, which compares hourly variations in B.O.D., S.S., and S.V.S. Data concerning S.S. and S.V.S. are average results of four 24-hour surveys, two conducted in October 1950, and two in May 1951. The October 1950 and May 1951 results are closely correlated, with the exception of one result on a sample collected at noon, October 16, 1950. It appears from figure 3 that the hourly variations of S.S. and S.V.S. follow closely the variations in B.O.D.

A composite curve of hourly variations in sewage flow for each day in the week is presented in figure 4. These data represent an average over a 3-week, typical, dry-weather period, July 21 to August 14, 1950. Figure 5 presents the variation in daily flow on the basis of percent of average flow for a curve which is a composite of Monday-through-Saturday figures.

Sewage-Treatment-Plant Operation

Data comparing the design of the sewage-treatment plant prior to consideration of its use for dual disposal of garbage and sewage, and after it was redesigned for dual disposal, are shown in table 6. Figure 6 presents a flow diagram of the plant.

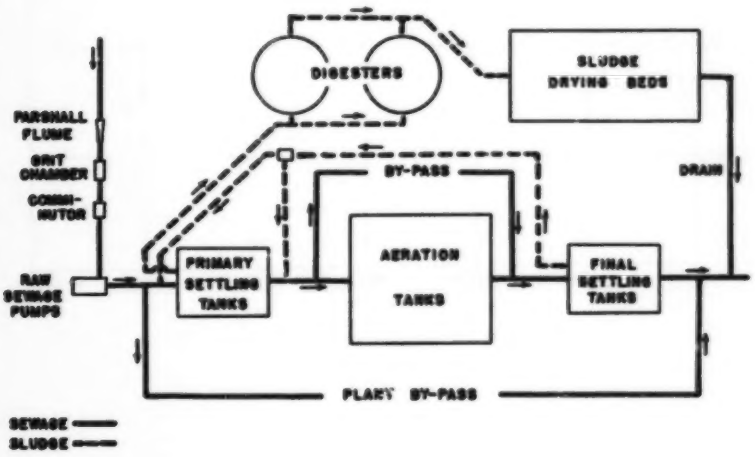

FIGURE 6.—*Flow Diagram—Jasper Sewage-Treatment Plant.*

TABLE 6.—*Design data—Jasper sewage-treatment plant*

Population 1950—5,041 Design population—10,500 (1975)

	Design data		
	Prior to considering treatment of garbage	With provisions for treating garbage	Additional capacity provided for garbage treatment
Design flow	1.0 M.G.D.	1.0 M.G.D.	None
Units			
Comminutor	One—15"	One—15"	None
Grit chamber	Mechanical	Mechanical	None
Primary settling	2 units—1.55-hr. detention; surface rate—1,040 gal/sq.ft/day; overflow rate—33,000 gal/ft/day.	2 units—1.55-hr. detention; surface rate—1,040 gal/sq.ft/day; overflow rate—33,000 gal/ft/day.	None
Final-settling tanks	2 units—2.6-hr. detention; 40' x 18' x 10' SWD; surface rate—750 gal/sq.ft/day.	2 units—2.6-hr. detention; 40' x 18' x 10' SWD; surface rate—750 gal/sq.ft/day.	None
Aeration tanks	2 units—5.2-hr. detention; 60' x 20' x 15' SWD; total vol.—36,000 cu.ft.	3 units—7.8-hr. detention; 60' x 20' x 15' SWD; total vol.—54,000 cu.ft.	1 unit—2.6-hr. detention; 60' x 20' x 15' SWD; vol.—18,000 cu.ft.
Sludge digester (s)	1 unit—45' dia. x 25' SWD; vol.—43,700 cu.ft.; cap—4.2 cu.ft./cap (design).	2 units—40' dia. x 26' SWD; vol.—68,760 cu.ft.; 6.6 cu.ft./cap. (design).	1 unit—vol.—25,060 cu.ft.; 2.4 cu.ft./cap.
Sludge beds	4 beds—50' x 100'; area—20,000 sq. ft.; cap—1.9 sq.ft/cap (design).	8 beds—40' x 100'; area—32,000 sq. ft.; 3.1 sq.ft/cap (design).	4 beds; area—12,000 sq. ft.; 1.2 sq.ft/cap.

Procedure.—At intervals since the sewage-treatment plant was placed in operation in June 1950, observations were made to determine the characteristics of operation of the various plant units. These observations were supplemented by laboratory analyses. The nature of the sampling surveys was discussed in the preceding section.

Presentation of data.—Three 2-week surveys were conducted approximately 1½, 3½, and 11 months after the sewage-treatment plant was first placed in operation.

Information on grit, primary sedimentation, raw sludge, and secondary treatment is presented in tables 7, 8, 9, 10, and 11, respectively.

Information on sludge digestion, including such factors as gas production and supernatant quality and quantity, is fragmentary, and a discussion of these features of plant operation is limited, for the most part, to personal observations.

In order to differentiate more clearly between those problems arising from the normal breaking-in of a new plant and those resulting from the combination of ground garbage and sewage, the following conditions should be kept in mind:

(a) Personnel employed to operate the treatment plant had no previous operating experience.

(b) The plant was placed in operation late in June 1950, and, as is common with new plants, a number of minor adjustments and changes in the physical features were made over a period of months following.

(c) As the result of interruptions in operation during some of these adjustments and changes, and as is natural in starting a new plant, routine operation was not finally established until late in the fall of 1950. By this time, a substantial number of household garbage-grinders had already been installed.

(d) During the winter of 1950–51, plant operation was again interrupted due to the failure of the 21-inch intercepting sewer, which permitted large quantities of surface and ground water to enter the system. Repairs were completed in May 1951.

(e) The treatment plant was designed to handle an average flow of 1.0 MGD. Although the organic load has been up to expectations, the dry-weather flow is exceptionally low, with peak average daily flows being only one-third of that for which the plant was designed.

Analysis of data.—The information obtained to date on plant operation is presented in four sections, entitled: (1) Grit Removal; (2) Sedimentation; (3) Collection of Sludge; and (4) Secondary Treatment.

(1) Grit Removal

The grit chamber at the Jasper treatment plant is rectangular in shape; its dimensions are 38′ x 6.5′, with a side-water depth of four feet. At design flow, sewage will be retained in the chamber approximately ten minutes. The theoretical velocity at design flow is 3.5 feet per minute. No velocity control is maintained through the channel; however, diffused air headers, located at the discharge end of the chamber immediately over the grit hoppers, are operated for the purpose of resuspending the lighter organic solids. Grit settled out in the upper reaches of the chamber is carried to the grit hoppers by a conventional, straight-line, sludge-scraper conveyer. Since the grit chamber is located about 20 feet below ground level, a grit elevator is used to remove grit collected in the hoppers.

Partially as the result of a lack of velocity control and the low flows encountered, and possibly because of the raw-sewage characteristics, grit removed from the chamber has exhibited exceptionally high concentrations of volatile solids, and has had an unusually high moisture content, as shown in table 7. Study of this table will reveal that in only one period of record, October 9 to 21, 1950, were flows typical of dry-weather conditions. On this occasion, the quantity of grit obtained was extremely high. Results obtained at that time have not been duplicated.

Of the remaining periods for which data are available, grit quantities ranged from 0.6 to 2.7 cf/MG of sewage. In view of the wide range of flows observed during these periods, it would be difficult to estimate the basic grit quantities which might be anticipated during dry-weather periods.

TABLE 7.—*Characteristics of grit*

Period	Average daily flow (MG)	Total flow (MG)	Wet grit		Total dry solids by weight (average percent)	Percent volatile solids		Remarks
			c.f.	c.f./MG		Range	Average	
October 9–21, 1950	0.240	3.123	16	14.7	22	75–90	82	2 weeks.
November 1950 [2]	1.04	26.093	42	1.61				25 days.
December 1950 [2]	.862	26.706	26	.97				30 days.
January 1951 [2]	(Due to excessive flows, no measurement of flow was made January 13–22, and no grit was collected.)							
February 1951 [2]		39.934	24[1]	.60				
March 1951 [2]	1.482	45.949	44[1]	.94				
April 1951 [2]	.753	22.618	62	2.7				
May 20–June 2, 1951	.502	7.039	10	1.4	26	72–89	79	2 weeks.

[1] Two main interceptor breaks.
[2] Data on sewage flow and quantity of grit obtained during period of November 1950 through April 1951 were taken from monthly operation reports; however, no chemical analysis on grit was recorded.

(2) Primary Sedimentation

Two rectangular tanks, each 32′ x 15′, with a 9-foot water depth, are used for primary sedimentation. These tanks are provided with straight-line, sludge-collector mechanisms, which transport settled sludge to hoppers located at the inlet end of each tank. Each tank has an overflow weir extending the width of the tank, and a slotted, cylindrical, channel-type scum collector which is manually operated. At design flow, these settling tanks provide 1.55 hours detention time, have a surface settling rate of 1,040 gallons per square foot of surface area, and a weir overflow rate of 33,000 gallons per foot of weir. During the periods reported herein, both settling tanks were in operation. Because of the low flows, detention times were greater than desirable except, perhaps, for the period May 20 to June 2, 1951.

Results tabulated and summarized in table 8 suggest that the effect of ground garbage was beneficial to the efficiency of the sedimentation process. Results of the two surveys conducted in October 1950 and May 1951 indicated B.O.D. and S.S. removals of approximately 40 and 75 percent respectively. The relatively low B.O.D. removal observed during the August 1950 period may have been due, in part, to the discharge of digester supernatant directly to the primary tanks in that period. Subsequent to that time, supernatant has been discharged directly to the aeration tanks. Another change in operation, which occurred after the August period, is also worthy of note: During the first few months of operation, waste-activated sludge was discharged to a sludge tank which receives raw sludge from the primary-settling tanks through a slip-pipe arrangement. This practice was abandoned during the month of September 1950, and from that time waste-activated sludge has been discharged to the primary tanks.

TABLE 8.—*Efficiency of primary sedimentation*

Date	Average daily flow (MGD)	Primary detention time (hours)	Surface rate (Gal./sq. ft./day)	Raw sewage			Primary effluent			Percent removal		
				B.O.D. (ppm)	S.S. (ppm)	S.V.S. (ppm)	B.O.D. (ppm)	S.S. (ppm)	S.V.S. (ppm)	B.O.D.	S.S.	S.V.S.
1950												
Aug. 1	0.367	4.23	382	265	222	.....	230	116	.....	13	48	.....
2	.325	4.78	338	298	282	.....	235	120	.....	21	57	.....
3	.332	4.68	346	380	275	.....	231	153	.....	39	44	.....
4	.293	5.30	305	239	276	.....	214	121	.....	10	56	.....
14	.350	4.44	364	580	586	.....	378	50	.....	35	92	.....
15	.327	4.75	340	412	410	.....	350	130	.....	15	68	.....
16	.346	4.49	360	347	352	.....	296	119	.....	15	66	.....
17	.323	4.80	336	339	456	.....	297	116	.....	12	75	.....
18	.311	5.00	324	256	382	.....	255	254	.....	0	33	.....
21	.286	5.43	298	512	526	.....	350	136	.....	32	74	.....
22	.264	5.89	275	317	300	.....	261	99	.....	18	67	.....
23	.258	6.01	268	405	408	.....	317	95	.....	22	77	.....
24	.285	5.45	296	364	380	.....	305	132	.....	16	65	.....
25	.259	6.00	269	346	479	.....	299	89	.....	14	82	.....
Oct. 9	.288	5.40	300	506	329	277	326	62	62	36	81	78
10	.259	6.00	269	372	373	290	257	99	83	31	73	75
11	.271	5.73	282	274	377	346	212	61	.....	23	84	.....
12	.229	6.79	238	277	315	263	177	121	77	36	62	71
13	.249	6.24	259	406	331	299	221	60	.....	46	82	.....
14	.270	5.75	281	271	417	371	160	106	63	41	75	83
15	.169	9.20	176	396	229	197	222	40	32	44	83	84
16	.251	6.19	261	647	672	594	342	170	167	47	75	71
17	.201	7.74	209	561	586	506	351	130	.....	37	78	.....
18	.253	6.15	263	371	393	303	231	132	.....	38	66	.....
19	.259	6.00	269	501	647	575	226	102	.....	55	84	.....
20	.210	7.40	218	317	409	326	237	112	.....	57	73	.....
21	.214	7.26	222	441	467	355	296	93	.....	33	80	.....
1951												
May 20	.373	4.16	388	294	454	.....	140	66	.....	52	85	.....
21	.530	2.93	551	505	416	320	385	82	.....	24	74	.....
22	.670	2.32	697	414	440	286	319	116	.....	23	74	.....
23	.572	2.71	595	423	442	398	280	114	107	34	77	73
24	.498	3.12	518	358	749	688	276	111	.....	23	85	.....
25	.509	3.05	529	313	423	327	243	136	.....	22	68	.....
26	.548	2.83	570	330	318	284	93	106	.....	72	67	.....
27	.366	4.24	381	365	343	262	140	162	.....	62	53	.....
28	.514	3.02	534	315	377	302	275	144	.....	13	62	.....
29	.488	3.18	507	[1] 109	420	329	107	59	.....	2	86	.....
30	.359	4.32	373	530	302	256	174	56	.....	67	82	.....
31	.481	3.22	500	588	413	345	246	105	.....	58	75	.....
June 1	.504	3.08	524	343	347	288	262	84	.....	24	76	.....
2	.627	2.48	652	254	446	.....	265	109	.....	.....	76	.....

Summary of results (average)

Aug. 1950	0.309	5.1	322	[illegible]62	381	.....	257	124	.....	21	68	.....
(14-24 hours) Oct. 9-21, '50	0.240	6.6	250	[illegible]10	426	362	250	99	81	39	77	[1] 76
May 20-June 2, 1951	0.502	3.2	524	[1]387	420	340	229	104	.....	41	75	.....

[1] Excluding the result of May 29, 1951.
[2] Based on average-suspended-solids tests run on days when S.V.S. tests were made.

(3) Raw-Sludge Characteristics

Raw sludge is removed from the primary-settling-tank sludge hoppers, through slip-pipes, into a sludge tank. Sludge is then pumped from this tank to the digesters, which are operated in series. The digesters are heated by external heat exchangers.

Samples of raw sludge were obtained during each of the three survey periods. Results of the analyses of these samples are presented in table 9. During the first sampling period in August 1950, the concentration of sludge solids was high, ranging from 4.6 to 7.4 percent, and averaging 5.8 percent, for six analyses. During the October 1950 survey, the average concentration of solids was 3.2 percent, rising to 4.3 percent in May 1951.

TABLE 9.—*Characteristics of raw sludge*

Date	Sewage flow (MGD)	Raw sludge data		
		Volume/day *gallon*	Total solids *percent*	Total volatile solids *percent*
1950				
July 30	0.229		7.4	73
Aug. 1	.367		4.6	65
Aug. 3	.332		5.7	71
Aug. 15	.327		7.2	72
Aug. 16	.346		4.6	74
Aug. 19	.320		5.5	75
Average			5.8	72
1950				
Oct. 10	0.259		3.7	73
Oct. 12	.229		1.9	55
Oct. 14	.270		2.1	76
Oct. 15	.169		2.6	73
Oct. 18	.253		4.5	69
Oct. 20	.210		4.2	76
Average			3.2	71
1951				
May 22	0.670	9,400	5.0	76
May 25	.509	7,840	4.8	75
May 27	.366	4,700	3.6	76
May 29	.433	7,050	4.2	77
June 1	.504	7,840	4.2	77
Average			4.3	76

In view of the fact that no waste-activated sludge was entering the primary tanks during the August 1950 period, it is likely that the results observed during that time were somewhat higher than those which might be expected under normal operating conditions. Therefore, the data presented, together with the results of tests made independently by the personnel of the treatment plant, indicate that normal concentrations of raw-sewage sludge, ranging from 3 to 4½ percent solids, are being encountered at Jasper. As might be expected, average concentrations of total volatile solids were high, ranging from 71 to 76 percent, the higher percentage being obtained during the May 1951 survey.

While only partial data are available concerning the operation of the digestion tanks, these units appear to be operating nor-

mally. Sufficient gas is being produced to supply the heat exchanger, as well as to provide for the intermittent operation of a gas-engine-driven blower. Sludge discharged to the drying beds appears to be well digested, according to its physical appearance and drying characteristics.

(4) Secondary Treatment

The activated-sludge process is used to provide secondary treatment of sewage. Three aeration tanks in parallel, each 60′ x 20′ with a 15-foot side-water depth, provide a detention time of 7.8 hours at design flow of 1.0 M.G.D. and 25 percent return sludge. Based on standard design criteria, these aerators have sufficient volumetric capacity to treat 1,800 lbs. B.O.D. in the primary effluent.

Two secondary-settling tanks, each 40′ x 18′ with a 10-foot side-water depth, provide a detention time of 2.6 hours at design flow, and a surface-flow rate of 750 gallons per square foot. The weir overflow rate is 7,350 gallons per foot of weir per day. Activated sludge settled out in the secondary-settling tanks is pumped to a sludge-diversion box. From there, waste sludge is directed to the primary-settling tanks, and return activated sludge is discharged to the aeration-tank channel. Two 175-gpm, centrifugal pumps are available as return-sludge pumps.

Compressed air is applied in the aeration tanks through swing-arm headers and Saran-wound diffuser tubes. Two blowers, each with a capacity of 500 cfm, are available. One of these units is electrically driven; the other is powered by a dual-fuel gas engine.

A summary of results, showing over-all plant efficiency and reflecting the performance of the secondary-treatment facilities, is presented in table 10. As can be seen, the results are erratic.

In reviewing the operating characteristics of the secondary-treatment facilities, shown in table 11, it appears that during the period in which the three 24-hour surveys were made, a normal biological balance had not been achieved. The causes of the difficulty in operation have not been specifically determined. Before a comprehensive study of the effect of ground garbage on the treatment plant could be considered, the correction of several conditions was necessary. These conditions are described as follows:

(a) The inability to provide sufficient air to the aeration tanks. (Cleaning out the air headers, and replacing and cleaning diffuser tubes, improved this situation after the first survey—August 1950—was made.)

(b) The inability to use more than one air compressor at a time, due to the creation of excessive pressures. (This was remedied after the May 1951 survey, by the installation of additional diffuser tubes in the headers.)

TABLE 10.—*Over-all plant efficiency*

Date	Average daily flow (MGD)	Raw sewage (ppm)		Final effluent (ppm)		Percent removal	
		B.O.D.	S.S.	B.O.D.	S.S.	B.O.D.	S.S.
1950							
Aug. 1	.367	265	222	33	12	86	95
Aug. 2	.325	298	282	17	12	94	96
Aug. 3	.332	380	275	28	9	93	97
Aug. 4	.293	239	276	47	27	80	90
Aug. 14	.350	580	596	70	29	88	95
Aug. 15	.327	412	410	.....	127	.....	69
Aug. 16	.346	347	352	.....	107	.....	70
Aug. 17	.323	339	456	.....	58	.....	87
Aug. 18	.311	256	382	23	6	91	98
Aug. 21	.286	512	526	44	12	91	98
Aug. 22	.264	317	300	62	56	80	81
Aug. 23	.258	405	408	111	88	73	78
Aug. 24	.285	364	380	21	9	94	98
Aug. 25	.259	346	479	20	8	94	98
Average	.309	362	381	44	40	88	89
1950							
Oct. 9	.288	506	329	11	4	98	99
Oct. 10	.259	372	373	17	13	96	97
Oct. 11	.271	274	377	11	1	96	100
Oct. 12	.229	277	315	54	29	81	91
Oct. 13	.249	406	331	23	14	94	96
Oct. 14	.270	271	417	60	27	78	94
Oct. 15	.169	396	229	31	16	92	93
Oct. 16	.251	647	672	100	73	85	89
Oct. 17	.201	561	586	48	17	91	97
Oct. 18	.253	371	393	79	45	79	89
Oct. 19	.259	501	647	137	156	73	76
Oct. 20	.210	317	409	138	157	56	62
Oct. 21	.214	441	467	109	82	75	83
Average	.240	410	426	63	49	84	90
1951							
May 20	.373	294	454	30	14	90	97
May 21	.530	505	416	19	10	96	98
May 22 (rain)	.670	414	440	75	62	82	86
May 23	.572	423	442	40	22	91	95
May 24	.498	358	749	63	46	82	94
May 25	.509	313	423	47	32	85	92
May 26 (rain)	.548	330	318	20	21	94	93
May 27	.366	365	343	14	24	96	93
May 28	.514	315	377	14	27	96	93
May 29	.488	109	420	8	8	93	98
May 30	.359	530	302	14	14	97	95
May 31	.481	588	413	55	55	91	87
June 1	.504	343	347	52	107	85	69
June 2 (rain)	.627	254	446	33	65	87	85
Average	.502	387	420	35	36	90	91

(c) During the winter months, excessive infiltration from major breaks in the main interceptor sewer to the plant (located on low ground) caused such high flows and diluted sewage that operation as an activated-sludge plant was not possible. (The breaks were repaired in May 1951.)

No work has been done on the investigation of plant operation, with the exception of sampling from various plant units. During the coming year, considerable attention will be placed on this phase of the Jasper project.

Refuse Collection and Disposal

Information was gathered from City officials and employees as to former methods and costs of refuse collection and disposal, and the method presently used to collect and dispose of rubbish.

TABLE 11.—*Operation data—Secondary-treatment facilities*

Date	Average daily flow (MGD)	Aeration-tank loadings: Primary effluent B.O.D. (ppm.)	Aeration-tank loadings: Primary effluent B.O.D. (pounds)	Aeration-tank loadings: Detention time[1] (hours)	Aeration-tank loadings: Tank volume (c.f./# B.O.D. applied)	Aeration-tank loadings: Air usage (c.f./# B.O.D. applied)	Mixed liquor analyses (average results): Settleable solids (percent)	Suspended solids (ppm.)	Sludge index	D.O.	Grease (ppm.)	Return sludge (ppm.)	Remarks
1950													
Aug. 1	0.367	230	703	17.6	51.3	1,025	14.0	920	152	2.1	.....	3,190	2 tanks.
Aug. 2	.325	235	636	19.9	56.5	1,130	13.0	1,187	110	1.8	.....	7,580	2 tanks.
Aug. 3	.332	231	640	19.5	56.3	1,125	8.2	1,067	77	1.8	.....	6,000	2 tanks.
Aug. 4	.293	214	522	22.1	69.0	1,380	9.0	1,071	84	2.1	.....	10,710	2 tanks.
Aug. 14	.350	378	1,102	18.5	32.6	653	60.0	1,115	540	1.3	.....	.....	2 tanks.
Aug. 15	.327	350	955	19.8	37.7	755	77.0	1,194	645	1.0	.....	4,640	2 tanks.
Aug. 16	.346	296	854	18.7	42.1	845	80.5	1,271	633	.7	.....	5,110	2 tanks.
Aug. 17	.323	297	798	20.0	45.1	905	76.5	1,406	544	1.0	.....	4,300	2 tanks.
Aug. 18	.311	255	660	31.1	81.9	1,090	65.0	1,048	325	1.1	.....	3,630	3 tanks.
Aug. 21	.286	350	835	33.9	64.7	863	50.0	1,332	319	1.7	.....	3,470	3 tanks.
Aug. 22	.264	261	574	36.8	94.2	1,255	79.0	1,299	600	.....	.....	3,600	3 tanks.
Aug. 23	.258	317	681	37.6	79.3	1,060	75.0	1,093	685	.....	.....	3,600	3 tanks.
Aug. 24	.285	305	724	22.7	49.8	995	90.0	1,175	765	.....	.....	4,010	2 tanks.
Aug. 25	.259	299	645	25.0	55.9	1,117	90.5	1,450	625	.....	.....	.....	2 tanks.
Oct. 9	.288	326	782	11.2	23.0	920	33.0	719	459	1.7	.....	1,300	1 tank.
Oct. 10	.259	257	555	12.5	32.4	1,300	52.0	792	651	1.0	.....	1,580	1 tank.
Oct. 11	.271	212	479	11.9	37.6	1,505	57.0	889	640	1.0	.....	2,180	1 tank.
Oct. 12	.229	177	338	14.1	53.3	2,130	67.0	854	785	.9	.....	1,740	1 tank.
Oct. 13	.249	221	458	13.0	39.3	1,570	51.0	688	740	.8	.....	780	1 tank.
Oct. 14	.270	160	360	12.0	50.0	2,000	72.0	751	947	2.2	.....	.....	1 tank.
Oct. 15	.169	222	312	19.1	57.8	2,310	80.0	.....	.....	2.2	.....	.....	1 tank.
Oct. 16	.251	342	715	12.9	25.2	1,010	68.0	.....	.....	.....	98	1,540	1 tank.
Oct. 17	.201	351	587	32.2	61.4	1,228	50.0	425	1,165	2.0	.....	1,110	2 tanks.
Oct. 18	.253	231	486	25.5	74.0	1,480	78.0	429	1,815	2.1	43	680	2 tanks.
Oct. 19	.259	226	488	25.0	73.9	1,475	62.0	361	1,710	2.7	.....	1,080	2 tanks.
Oct. 20	.210	237	414	30.8	87.0	1,740	86.0	346	2,475	1.3	.....	910	2 tanks.
Oct. 21	.214	296	527	30.2	68.3	2,440	85.0	330	2,565	2.3	.....	1,160	2 tanks.
1951													
May 20	.373	140	435	26.0	124.2	1,655	11.0	770	143	2.7	.....	.....	3 tanks.
May 21	.530	385	1,700	18.3	31.8	424	11.0	790	139	1.2	.....	6,080	3 tanks.
May 22 (rain)	.670	319	1,780	14.5	30.4	405	13.0	801	162	1.5	.....	2,970	3 tanks.
May 23	.572	280	1,335	17.0	40.5	540	12.0	708	170	1.3	139	3,980	3 tanks.
May 24	.498	276	1,146	19.5	47.1	630	12.0	689	188	1.4	.....	1,830	3 tanks.
May 25	.509	243	1,030	19.1	52.5	700	14.0	834	168	3.1	19	1,960	3 tanks.
May 26 (rain)	.548	93	425	17.7	127.1	1,695	19.0	736	258	1.9	.....	2,830	3 tanks.
May 27	.366	140	427	26.5	126.5	1,685	22.0	879	274	1.7	.....	2,750	3 tanks.
May 28	.514	275	1,177	18.9	46.0	611	17.0	791	215	1.2	70	3,360	3 tanks.

May 29	.488	107	435	19.9	124.2	1,655	25.0	823	401	1.0	92	6,200	3 tanks.
May 30	.359	174	520	27.0	104.0	1,385	33.0	807	409	2.1	.....	2,650	3 tanks.
May 31	.481	246	987	20.2	54.8	730	30.0	728	412	1.7	.....	2,460	3 tanks.
June 1	.504	262	1,100	19.3	49.1	655	38.0	719	529	1.3	.....	2,660	3 tanks.
June 2 (rain)	.627	265	1,382	15.5	39.0	520	31.0	998	382	1.5	101	3,960	3 tanks.

[1] Without return sludge.

Personal observation was used to determine current rubbish-storage practices by individual householders.

Prior to August 1, 1950, household garbage was collected by a private scavenger, under contract with the City. At the time of discontinuance, the contract was for $6,000 annually. The scavenger utilized two 1-ton trucks having low-slung, uncovered, metal bodies. The contract called for a minimum of two collections from each home each week. It was sometimes necessary to make more frequent collections during summer months; on the other hand, the semi-weekly schedule was not always met during inclement weather. The scavenger disposed of the garbage by feeding it uncooked to hogs. The City experienced no difficulty with this method of disposal until 1947, when an outbreak of hog cholera occurred in a herd of the garbage-fed hogs. The City was then faced with difficulty in obtaining bidders, despite a considerable increase in contract price. A City ordinance stipulated specifications of garbage containers, their location, etc. The householder was notified of violations through City notices left by the scavenger.

After regular garbage collection was discontinued, householders without grinders appeared to be disposing of garbage in compliance with the new City ordinance. To date, no application has been received by the City for a permit to collect and dispose of garbage commercially.

Rubbish was, and is, collected by the City. The equipment, used part-time for rubbish collection, includes two 1½-ton, open, wooden-body trucks, each with a crew of three men. Rubbish is scheduled for collection from each home once every three weeks, but this schedule is not met occasionally, because of either inclement weather or priorities for use of the trucks on street repairs.

Rubbish disposal is at a City-owned open dump, where a full-time caretaker is on duty. It should be noted that the majority of home owners without grinders dispose of garbage at the dump individually. In addition, garbage and rubbish from commercial and industrial establishments are deposited here.

The cost of rubbish collection and disposal is approximately $2.36 per capita per year.

The annual costs, as reported by the Mayor, chargeable to rubbish collection and disposal are:

Salaries of rubbish collectors	$9,140
Salary of dump caretaker	1,800
Depreciation of equipment, and equipment operation	1,367
Total	12,307

During a survey in June 1951, observations were made regarding the status of refuse-storage practices in Jasper. The criteria used in this evaluation were:

Excellent—Ideal storage standards met. (In case of garbage, also includes those homes with grinders.)

Good—Effort made; minimum requirements met.

Fair—Effort made; minimum requirements not met.

Poor—No effort made.

The following definitions are applicable to this study.

Garbage—Animal and vegetable waste resulting from the handling, preparation, cooking, and consumption of foods.

Rubbish—All refuse other than garbage and ashes.

Salvage—Any accumulation of materials, such as products of remodeling, refurnishing, and by-products operations, other than current supplies or materials of business, retained on premises by occupant. Includes firewood, kindling, used lumber, etc.

Table 12 indicates the status of refuse-storage practices at the time of observation. The occupants of 94 percent of the homes and establishments were storing garbage in a satisfactory manner; i. e., they were meeting the "excellent" or "good" criteria given above. The percentage of homes and establishments providing satisfactory rubbish and salvage storage was somewhat lower, being 80 percent in the case of rubbish storage, and 68 percent for the storage of salvage.

TABLE 12.—*Refuse-storage practices—June, 1951*

Location and type of material	Total no.	Storage practices				
		Excellent	Good	Fair	Poor	None
Food establishments	22					
Garbage		14	3	3	2	
Rubbish		12	4	4	2	
Salvage		13	2	3	4	
Interior food storage		14	2	2	4	
Feed mills	3					
Garbage						3
Rubbish			1		2	
Salvage				2	1	
Interior feed storage			2	1		
Private premises—south of 6th St.	128					
Garbage		[1] 72	47	4	5	
Rubbish		49	41	12	26	
Salvage		43	34	17	34	
Private premises—north of 6th St.	480					
Garbage		[1] 449	11	2	18	
Rubbish		225	172	48	5	
Salvage		331	6	18	25	

[1] Includes those with no exterior garbage storage.

Fly Densities

Procedure.—As fly densities had not been determined in Jasper before the initiation of this study, it was necessary to select a neighboring community as a control. The City of Huntingburg,

located seven miles south of Jasper, was selected for this purpose, because of its proximity and its similarity in characteristics.

The Scudder fly-grill method[1] of fly sampling was utilized, using an 18-inch grill. Surveys were made during the weeks of August 21 and September 11, 1950, and June 11 and September 10, 1951. During the 1950 counts, 48 blocks were surveyed in Jasper and 28 in Huntingburg. These were reduced, in June 1951, to 26 blocks in Jasper and 13 in Huntingburg, because of inclement weather, and the same numbers were utilized in September 1951. The five highest readings were recorded, in each block and at the open dumps in the two communities. Meteorological data were secured from the U. S. Weather Bureau at Evansville, Indiana, about 42 airline miles distant.

Presentation of Data.—Tables 13 and 14 present data regarding fly densities in Jasper and in Huntingburg.

Analysis of Data.—At the time of the 1950 fly-density surveys in Jasper, the regular collection of garbage had very recently been discontinued. Many accumulations of garbage in improperly-constructed containers were noted, as well as a general relaxation in community attitude toward sanitation. In Huntingburg, there was a noticeable increase in the number of new, approved containers between the first and second surveys, resulting from a conference between the Mayor and the surveyors.

TABLE 13.—*Fly-species densities—Jasper and Huntingburg*

Species	Week	Total no. of flies counted		Average no. of flies per grill count		Percent of total flies	
		Jasper	Huntingburg	Jasper	Huntingburg	Jasper	Huntingburg
Musca domestica	Aug. 21, 1950	292	181	1.2	1.3	26.7	24.5
	Sept. 11, 1950	622	159	2.6	1.1	41.0	24.6
	June 11, 1951	91	12	.7	.2	33.0	5.5
	Sept. 10, 1951	651	895	5.0	13.8	59.5	55.6
Phaenicia	Aug. 21, 1950	734	507	3.1	3.6	67.0	68.5
	Sept. 11, 1950	833	455	3.5	3.3	55.0	70.7
	June 11, 1951	131	125	1.0	1.9	47.5	56.8
	Sept. 10, 1951	364	403	2.8	6.2	33.3	25.1
Others	Aug. 21, 1950	69	52	.3	.4	6.3	7.0
	Sept. 11, 1950	60	31	.2	.2	4.0	4.7
	June 11, 1951	54	83	.4	1.3	19.5	37.7
	Sept. 10, 1951	78	313	.6	2.4	7.2	19.3

Meteorological conditions during the surveys were generally satisfactory. During the June 1951 survey in Jasper, only four of the 26 blocks revealed fly-breeding in garbage, and then only to a minor extent. In Huntingburg, eight of the 13 blocks surveyed contained one to several instances of fly-breeding, either in garbage placed in containers, or in material on the ground. In September 1951, 11 of the 26 blocks surveyed in Jasper were posi-

[1] Scudder, H. I.: "A New Technique for Sampling the Density of Housefly Populations," *Pub. Health Rep.* 62 : 681–686 (May 9, 1947).

tive for fly-breeding in household garbage, while seven of the 13 blocks surveyed in Huntingburg contained readily-detectable sources of fly-production. (It should be noted that there was a general relaxation of sound garbage-storage practices at the time of the latter survey, because it was the peak of the fall home-canning season.)

On the basis of comparative presence and magnitude during the surveys in 1951, the fly-production from household garbage in Jasper could be rated as being of "medium" intensity, while that in Huntingburg was "very heavy." In both communities, the improper storage of rubbish between collections was rather evident at all times, and some garbage was seen in the rubbish containers.

TABLE 14.—*Comparison of fly densities in Jasper and Huntingburg*

Week	City	Blocks surveyed	No. of flies counted		Average no. of flies per grill count		Count ratio, Huntingburg/ Jasper
			City	Dump	City	Dump	
Aug. 21, 1950	Jasper	48	1,095	84	4.5	16.8	1.2
	Huntingburg	28	740	229	5.3	45.8	
Sept. 11, 1950	Jasper	48	1,515	266	6.3	53.2	.7
	Huntingburg	28	645	322	4.3	64.4	
June 11, 1951	Jasper	26	276	56	2.1	11.2	1.6
	Huntingburg	13	220	47	3.4	9.4	
Sept. 10, 1951	Jasper	26	1,093	660	8.4	132.0	3.0
	Huntingburg	13	1,611	610	24.8	122.0	

The data in table 14 indicate a relationship between the size of grill counts in the 1951 surveys and the intensity of fly-breeding found in domestic garbage. While seasonal trends in fly populations cannot be extrapolated from a few surveys, observations to date indicate that a reduction in fly-breeding due to garbage has resulted from the change in garbage-handling practices. In September 1951, the average grill counts were approximately three times as high in Huntingburg as in Jasper. A marked increase in fly densities in both cities, over that found in June 1951, emphasized the relative difference in densities.

Observations outside the city limits of Jasper, during the June 1951 survey, revealed that several establishments adjacent to the northeastern section were capable of heavy fly-production. This was reflected in the total number of flies counted within the city limits. It was noted that *Musca domestica* was more prevalent in the northeastern section than in other parts of the city. This increased prevalence might be attributed to the presence of breeding areas in the manure from dairy barns and slaughterhouse pens adjacent to the northeastern section.

In September 1951, *Musca domestica* comprised over 55 percent of all of the flies counted in each city. It should be noted that

the night temperatures were generally lower during the June 1951 survey, and the fly season may not have progressed sufficiently to produce numbers of *Musca domestica* comparable to those detected during the other surveys. Table 13 indicates that there has been no significant change in species composition over the past two seasons in either Jasper or Huntingburg.

The city dumps in both Jasper and Huntingburg were, and continue to be, sources of large fly populations. Of significance is the increase in fly densities at the Jasper dump since the time of the initial survey. The rather large increase in the numbers of flies between the first and second surveys was probably due to the increased use of the dump by home owners without garbage-grinders, after the City discontinued garbage collection. This condition appeared to be accentuated at the time of the last survey. The Jasper dump had not been used for garbage disposal while the City provided collection service.

While the study of fly densities is particularly in need of additional survey data before conclusions may be drawn, it is felt that the environmental conditions during the September 1951 observations were more nearly representative of those required to judge the influence of the garbage-grinders on the fly population. Certain aforementioned factors have had some effect on the other results recorded in this report.

Because flies which are ordinarily present in small cities such as Jasper infiltrate from many sources, it would be unwise to expect that any system of garbage disposal, no matter how effective, would eliminate all flies. The elimination of most of the garbage cans, however, should influence fly densities within the city limits to a large degree. Observations indicated that animal pens, privies, etc., were common within both Jasper and Huntingburg. In Jasper, the privies were concentrated in the areas immediately within the city limits; while, in Huntingburg, they were distributed more generally. The open dumps adjacent to both cities certainly have a direct bearing on their fly populations.

Rodent Infestation

Procedure.—Two rodent-population surveys have been conducted, one in April-May 1950, and the other in June 1951. Since no previous rodent surveys had been conducted, the 1950 survey was used as a base to represent rodent-population characteristics in Jasper prior to the installation of garbage-grinders.

The entire premises of food establishments, the exterior premises of private homes, and the municipal dump grounds were examined for recent signs of rodents. The relative abundance of rodents in each case was determined by the following guides:

Very heavy.—Live rats seen; many freshly-dug or presently-used burrows; many fresh, pliable droppings; evidence of recent gnawings; sharply-defined footprints.

Medium heavy.—No live rats seen; several active burrows; plentiful fresh, pliable droppings; some recent gnawings; a few sharply-defined footprints.

Medium.—No live rats seen; some active burrows; some fresh, pliable droppings; a few recent gnawings; a few sharply-defined footprints.

Light.—No live rats seen; one or two active burrows; a few fresh, pliable droppings; recent gnawings; footprints.

None.—No signs of recent infestation.

For the 1950 survey, the selection of residential premises for examination was limited to those offering the greatest, potential, rodent infestation. In the 1951 survey, inspections were made of the same premises, plus all premises within a majority of the blocks containing previously-inspected sites. Three additional food establishments were surveyed in 1951. It should be noted here that none of the commercial food establishments has as yet installed a garbage-grinder.

Presentation of data.—Table 15 shows the degree of rodent infestation noted during the two surveys. Approximately one-third of the area of the city is located south of Sixth Street. This street runs east and west through the town square, generally forming a line of demarcation between the principal industrial-commercial area and the residential area.

TABLE 15.—*Degree of rodent infestation*

Location and time of survey	Total number of inspections	Degree of infestation									
		Very heavy		Medium heavy		Medium		Light		None	
		Number	Percent of total	Number	Percent of total	Number	Percent of total	Number	Percent of total	Number	Percent of total
Food establishments:											
April 1950	19	2	10.5	1	5.3	2	10.5	0	.....	14	73.7
June 1951	22	.....	.....	.....	.....	.....	.....	2	9.1	20	90.9
Feed mills:											
April 1950	1	1	100.0	.....	.....	.....	.....	.....	.....	.....	.....
June 1951	3	1	33.3	0	.....	1	33.3	1	33.3	.....	.....
Private premises—south of 6th St.											
May 1950	23	.....	.....	.....	.....	.....	.....	15	65.2	8	34.8
June 1951	[1] 23	.....	.....	.....	.....	1	[illegible]	9	39.1	13	56.5
June 1951	[2] 128	.....	.....	.....	.....	6	4.6	46	36.0	76	59.4
Private premises—north of 6th St.											
May 1950	49	.....	.....	.....	.....	.....	.....	19	38.9	30	61.1
June 1951	[1] 49	1	2.0	.....	.....	.....	.....	14	28.6	34	69.4
June 1951	[2] 480	.....	.....	.....	.....	.....	.....	29	6.0	451	94.0

[1] Premises inspected May 1950 and reinspected June 1951.
[2] Included, in most instances, all premises within block of reinspected premises and some additional blocks.

The city dump was noted to be heavily infested in both surveys. For example, during the 1951 survey, on an inspection at 10 o'clock one evening, approximately 50 rats were observed feeding on the exposed face of the dump. Most of the refuse deposited on the dump is rubbish; however, a considerable amount of garbage is deposited daily by home owners who do not have garbage-grinders, and by merchants. A large portion of the domestic rubbish consists of unwashed food containers.

Analysis of data.—There was considerably less evidence of rodent infestation in food establishments during the 1951 survey. It is believed that this was due, in part, to improvement in housekeeping practices, possibly resulting from the attention focused there by the various studies. None of the food establishments has as yet installed a garbage grinder.

All of the feed mills inspected were south of Sixth Street. While the operators have given considerable attention to rodent control in feed-storage areas, the enclosed spaces under the frame buildings remain as the main sources of rodent harborage. Such enclosures are required by fire regulations.

Based upon these samples, it was noted that there was a marked difference in the general rate of infestation between the areas south and north of Sixth Street. Of the 23 residential premises inspected south of Sixth Street in 1950, 65 percent were rodent-infested. On reinspection in 1951, only 42 percent of these premises remained infested. In this area, 105 additional residential premises were inspected in 1951: 36 percent of the total of 128 were found to be infested. Infestation of residential premises was confined primarily to areas adjacent to alleys. It should be noted that 42 of the 46 infestations were related directly to the presence of animal pens, and to coal- or salvage-storage sheds. The majority of such harborages consisted of frame buildings with wooden floors a few inches above the ground.

In 1950, of 49 residential premises north of Sixth Street inspected, 29 percent were infested. A re-survey of these premises in 1951 revealed that 29 percent were infested. In 1951, an additional 431 premises were inspected, representing all premises in the blocks containing the original 49. Only 6 percent of the total of 480 premises were found to be infested. All of the 29 infestations were related directly to animal pens, and to coal- or salvage-storage sheds. The degree of infestation in this area was generally lower than that observed in the area south of Sixth Street.

The unapproved storage of rubbish containing food particles does contribute to the maintenance of a rodent population, as does the improper storage of salvage material (see table 12). The relationship between rodent infestation and animal pens has been

mentioned previously. In this connection, it should be noted also that, at several locations, the practice of garbage disposal to those pens intensified the attraction to rodents there.

Before greater reductions in the rodent population can be effected, improvement in refuse-storage practices is necessary. The large numbers of rodents maintained at the dump grounds and at the feed mills will continue to be a source of reinfestation of harborage sites in the southern part of the city; therefore, the control of these locations must also be improved. The improvement in community sanitation, to which the installation of garbage-grinders has made a definite contribution, has resulted in a marked reduction in rodent infestation in Jasper. However, additional anti-rat measures are needed, to secure practical eradication.

Morbidity and Mortality Trends

A careful review was made of the morbidity and mortality records in the Indiana State Board of Health, in order to determine the frequency of diseases attributable to faulty sanitation practices. The information indicated that the number of cases and/or deaths reported for Jasper and for Dubois County were so few in number that it was not possible to utilize these data for the purposes intended.

Summary of Report

1. This is the first report of a joint investigation, by the U. S. Public Health Service and the Indiana State Board of Health, into the effects on community sanitation of the city-wide installation of garbage-grinders in Jasper, Indiana.

2. At the present time, over 900 household garbage-grinders have been installed, serving 75 percent of the population of Jasper.

3. There has been no noticeable per capita increase in residential water consumption.

4. There appears to be no deleterious effect on the sewers observed in Jasper, as the result of the introduction of ground garbage. These sanitary sewers range in size from 6 to 12 inches in diameter, and have grades providing theoretical velocities of from 1.75 to 6.8 feet per second.

5. An increase in organic load, as indicated by the B.O.D. contributed per capita, was observed during the period in which the number of persons, with homes connected to the sewer system and having garbage-grinders, increased from 8 to 72 percent. The increase in B.O.D. was from 0.12 to 0.18 lb. B.O.D. per capita. These results were obtained during dry-weather periods. During wet-weather periods, both before and after the grinder installations, organic loadings observed were appreciably higher.

6. The organic load attributable to ground garbage cannot be definitely fixed on the basis of information collected to date. It has varied from 65 to 100 percent of the sewage load in terms of lb. B.O.D. per capita; from 0 to 100 percent in terms of suspended solids; and from 20 to 90 percent in terms of suspended volatile solids.

7. Quantities of grease observed during typical dry-weather periods, at a time when 72 percent of the sewered population was served by garbage-grinders, was 0.07 lb. per capita per day. The average concentration of ether-soluble materials for a 2-week, 24-hour-per-day sampling period was 161 ppm. This, again, was for a typical dry-weather period. Quantities of grease reported during wet-weather periods were considerably higher.

8. A comparison of hourly variations in loading over 24-hour periods indicates that there is relatively little difference in the range of B.O.D. loadings (based on percent of daily average which might be attributed to the introduction of ground garbage through household grinders). Peak B.O.D. loadings were observed to be in the neighborhood of 250 percent of average.

9. Sufficient data have not been compiled during dry-weather periods to report accurately the quantities of grit which might be typical of this type of installation. The grit, however, has shown a tendency toward unusually high concentrations of volatile solids (around 80 percent) and a high moisture content (74 to 78 percent). The characteristics of the grit chamber may have some bearing on the type of grit observed.

10. Concentrations of raw sewage have been observed to range from 228 ppm B.O.D. (with 8 percent grinders) to 410 ppm (with 72 percent grinders). These are average figures, for 3 days and for 13 days, respectively. Maximum 24-hour (daily) average B.O.D. concentrations observed during periods of sampling reported here were 647 ppm. During the 13 days for which the average B.O.D. was 410 ppm, the total flow was 0.24 MGD, or only 52 gpcd, based on the connected population.

11. Efficiency of primary sedimentation units appeared to be unusually high, providing average suspended-solids removal of between 68 and 75 percent during each of the three sampling periods. B.O.D. removals during the periods when supernatant was not being returned to the primary-settling tanks averaged 40 percent. Detention times were high, and surface settling rates correspondingly low; however, there was no indication that the efficiencies observed would not continue under more normal periods of sedimentation.

12. Results of analyses for a limited period indicated raw-sludge concentrations from 4.6 to 7.4 percent (average 5.8 percent for 6 days) during a period when no waste-activated sludge

was present; the average volatile solids content was 72 percent. During subsequent periods, in the presence of waste-activated sludge, this concentration dropped to between 3 and 4 percent; the volatile-solids content varied from 71 to 76 percent.

13. Because of the usual operational difficulties accompanying the breaking-in of a new plant, results of secondary treatment were erratic, with treatment efficiencies approaching expectations at times, but inconsistently. The investigation of operation, and experimental control, were not attempted during the phase of the study reported here. Emphasis will be placed on the operation of the plant during the coming year, to enable a complete report on this subject to be made.

14. Plans for the Jasper sewage-treatment plant, prepared prior to the decision to dispose of food wastes with sewage, were revised to include ground garbage, by increasing the capacity of aeration facilities by 50 percent and the digestion tanks and sludge-drying beds by about 60 percent.

15. The occupants of approximately 94 percent of the homes and establishments examined in Jasper during June 1951 were either storing garbage on the premises in a satisfactory manner or utilizing garbage-grinders. The increased intensity in fly-breeding observed in household garbage in September 1951, during the peak of the home-canning season, emphasizes the need for continuous maintenance of satisfactory storage practices on premises where garbage-grinders are not used. The proportions of homes and establishments providing satisfactory storage of rubbish and salvage were somewhat lower. Only rubbish is collected by the City at this time; it is collected once every three weeks, with disposal at a City-owned open dump.

16. While seasonal trends of fly populations cannot always be determined from a limited number of surveys, there is some indication that the lower average number of flies per grill count in Jasper, when compared with the control town of Huntingburg, is related to the improved garbage-handling practices in Jasper. There are other sources of fly-breeding common to both cities, such as open dumps, animal pens, rubbish, etc., which must be controlled in order for flies to be reduced to a minimum.

17. The open dump owned by the City of Jasper was observed to be a major source of flies and rodents. This dump receives rubbish collected by the City, and garbage deposited by merchants and home owners who do not have garbage-grinders.

18. South of Sixth Street lies an area containing many commercial and industrial establishments, in which the rate of rodent infestation decreased between surveys of the same premises. During the 1951 survey, a large number of additional premises also

was inspected, and the rate was slightly lower than that for the selected premises. Most of the infestations noted were related directly to the presence of animal pens and storage sheds. The degree of infestation was higher than that observed in the area north of Sixth Street.

19. North of Sixth Street lies a predominantly residential area, in which the rate of rodent infestation decreased slightly between surveys, of the same premises. When a much larger sample was considered in this area, during the 1951 survey, the rate of infestation was considerably lower than that observed for the group of selected premises. Most of the infestations noted were related directly to animal pens, storage sheds, and open salvage storage.

20. Harborage for large numbers of rodents is provided by improper rubbish and salvage storage, animal pens, storage sheds, and feed mills, in addition to the open dump. Since buildings with interior rat populations, and premises with rats under removable harborages, replenish populations reduced by other measures, ratproofing and harborage-removal are essential parts of rodent-control programs. All contributory factors must be controlled in order for rodents to be reduced to a practical minimum.

Acknowledgments

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Appendix

TABLE 16.—*Analytical data relating to characteristics of raw sewage*

Date of survey	Population served [1]		Avg. flow	B.O.D.			Total solids			Total volatile solids			Suspended solids			Suspended volatile solids			Grease		
	By sewers	By grinders	(MGD)	ppm	lb.	lb./cap.	ppm	lb.	lb./cap.	ppm	lb.	lb./cap.	ppm	lb.	lb./cap.	ppm	lb.	lb./cap.	ppm	lb.	lb./cap.
Mar. 8, 1950			0.256	235	501	0.12	780	1,664	0.39	405	865	0.20	316	674	0.15	292	624	0.14			
Mar. 9, 1950			.247	275	566	.13	796	1,640	.38	317	652	.15	504	1,038	.24	248	510	.12			
Mar. 11, 1950			.330	174	478	.11	606	1,670	.39	293	805	.19	304	835	.19	248	681	.16			
Average for period	4,310	330	.278	228	515	.12	727	1,658	.39	338	774	.18	375	849	.19	263	605	.14			
Mar. 21, 1950			.461	208	800	.19	697	2,680	.62	313	1,200	.28	290	1,115	.26	236	907	.21	72	277	.06
Mar. 22, 1950			.415	221	764	.18	734	2,540	.59	337	1,165	.27	252	871	.20	210	725	.17	61	211	.05
Mar. 23, 1950			.400	245	817	.19	690	2,300	.53	313	1,042	.24	188	627	.15	164	547	.13	247[2]	824[2]	.19
Mar. 24, 1950			.400	[2]168	560	.13	617	2,055	.48	300	1,000	.23	168	560	.13	164	547	.13	90	300	.07
Mar. 25, 1950			.407	256	870	.20	626	2,125	.49	320	1,085	.25	208	706	.16	196	665	.15	100	339	.08
Average for period	4,310	330	.417	217	762	.18	673	2,340	.54	328	1,098	.25	221	776	.18	194	678	.16	81	282	.07
Aug. 1, 1950			.367	265	811	.18							222	679	.15						
Aug. 2, 1950			.325	298	808	.18							282	764	.17						
Aug. 3, 1950			.332	380	1,051	.23							275	780	.16						
Aug. 4, 1950			.293	239	583	.13							276	674	.15						
Aug. 14, 1950			.350	580	1,692	.37							586	1,710	.37						
Aug. 15, 1950			.327	412	1,123	.24							410	1,118	.24						
Aug. 16, 1950			.346	347	1,000	.22							352	1,015	.22						
Aug. 17, 1950			.323	339	912	.20							456	1,225	.27						
Aug. 18, 1950			.311	256	663	.14							382	990	.21						
Aug. 21, 1950			.286	512	1,220	.26							526	1,250	.27						
Aug. 22, 1950			.264	317	697	.15							300	660	.14						
Aug. 23, 1950			.258	405	870	.19							408	890	.19						
Aug. 24, 1950			.285	364	864	.19							380	901	.20						
Aug. 25, 1950			.259	346	746	.16							479	1,030	.22						
Average for period	4,620	3,060	.309	362	932	.20							381	976	.21						
Oct. 9, 1950			0.288	506	1,212	.26	824	1,975	.43	336	806	.17	329	790	.17	277	665	.14	147	353	.08
Oct. 10, 1950			.259	372	803	.17	945	2,040	.44	550	1,185	.26	373	805	.17	290	625	.14	188	405	.09
Oct. 11, 1950			.271	274	619	.13	819	1,850	.40	472	1,065	.23	377	851	.18	346	781	.17	151	341	.07
Oct. 12, 1950			.229	277	529	.11	951	1,815	.39	615	1,173	.25	315	601	.13	263	502	.11	148	283	.06
Oct. 13, 1950			.249	406	842	.18	770	1,595	.35	490	1,015	.22	331	687	.15	299	620	.13	119	247	.05
Oct. 14, 1950			.270	271	610	.13	818	1,840	.40	510	1,145	.25	417	939	.20	371	835	.18	161	362	.08
Oct. 15, 1950			.169	396	557	.12	772	1,088	.24	500	705	.15	229	323	.07	197	278	.06	105	148	.03
Oct. 16, 1950			.251	647	1,352	.29	912	1,905	.41	646	1,350	.29	672	1,405	.30	594	1,240	.27	221	462	.10

Oct. 17, 1950			.201	561	940	.20	1,065	1,785	.39	720	1,205	.26	586	982	.21	506	850	.14	160	268	.06
Oct. 18, 1950			.253	371	783	.17	1,103	2,330	.50	639	1,460	.32	393	828	.18	303	638	.18	183	386	.08
Oct. 19, 1950			.259	501	1,081	.23	1,319	2,840	.62	901	1,940	.42	647	1,395	.30	575	1,240	.27	202	433	.09
Oct. 20, 1950			.210	317	555	.12	964	1,690	.37	651	1,140	.25	409	716	.16	326	571	.12	142	249	.05
Oct. 21, 1950			.214	441	786	.17	1,025	1,830	.40	710	1,265	.27	467	833	.18	355	633	.14	221	394	.09
Average for period	4,620	3,300	.240	410	826	.18	945	1,890	.41	600	1,190	.26	426	858	.20	362	730	.16	161	333	.07
May 20, 1951			.373	294	915	.19	752	2,335	.49	515	1,600	.33	454	1,410	.29				168	522	.11
May 21, 1951			.530	505	2,230	.47	1,668	7,355	1.54	1,172	5,170	1.08	416	1,837	.38	320	1,412	.30	176	777	.16
May 22, 1951 [3]			.670	414	2,310	.48	1,096	6,120	1.28	640	3,570	.75	440	2,453	.51	286	1,595	.33	183	1,021	.21
May 23, 1951			.572	423	2,020	.42	1,066	5,080	1.06	632	3,012	.63	442	2,106	.41	398	1,895	.40	213	1,015	.21
May 24, 1951			.498	358	1,485	.31	1,282	5,320	1.11	817	3,385	.71	749	3,102	.65	688	2,850	.60	234	970	.20
May 25, 1951			.509	313	1,325	.28	628	2,660	.56	449	1,903	.40	423	1,791	.37	327	1,385	.29	169	716	.15
May 26, 1951 [3]			.548	330	1,505	.31	831	3,790	.79	596	2,720	.57	318	1,451	.30	284	1,296	.27	181	826	.17
May 27, 1951			.366	365	1,115	.23	638	1,945	.41	314	957	.20	343	1,045	.22	262	799	.17	148	451	.09
May 28, 1951			.514	315	1,350	.28	1,176	5,030	1.05	686	2,938	.61	377	1,613	.34	302	1,291	.27	204	872	.18
May 29, 1951			.488	[2]109	[4]443	.09	966	3,930	.82	704	2,860	.60	420	1,710	.36	329	1,339	.28	196	805	.17
May 30, 1951			.359	530	1,585	.33	915	2,740	.59	469	1,402	.29	302	904	.19	256	766	.16	128	383	.08
May 31, 1951			.481	588	2,360	.49	1,806	7,240	1.51	1,496	6,000	1.25	413	1,650	.35	345	1,381	.29	173	694	.15
June 1, 1951			.504	343	1,440	.30	942	3,950	.83	568	2,383	.50	347	1,455	.30	288	1,209	.25	185	777	.16
June 2, 1951 [3]			.627	254	1,330	.28	860	4,490	.94	685	3,575	.75	446	2,326	.49				166	865	.18
Average for period	4,790	3,650	.502	387	1,610	.34	1,045	4,423	.92	695	2,960	.62	420	1,776	.37	340	1,435	.30	180	764	.16
Corrected for poultry plant wastes					1,480	.31		4,230	.88		2,820	.59		1,650	.34		1,380	.29		747	.16

[1] 4.2 persons per sewer connection and grinder installation.
[2] Not included in averages.
[3] Rain.

TABLE 17.—*Hourly variations in raw-sewage characteristics*

Time	Flow (MGD)	Total solids (ppm)	Total volatile solids (ppm)	Percent volatile solids	Suspended solids (ppm)	Suspended volatile solids (ppm)	Percent suspended volatile solids	B.O.D. (ppm)
Mar. 8, 1950 (Wednesday):								
8 a.m.	0.324	.....	.....	.....	.....	.....	.....	237
10 a.m.	.363	.....	.....	.....	.....	.....	.....	291
12 noon	.389	.....	.....	.....	.....	.....	.....	242
2 p.m.	.424	.....	.....	.....	.....	.....	.....	312
4 p.m.	.406	.....	.....	.....	.....	.....	.....	229
6 p.m.	.355	.....	.....	.....	.....	.....	.....	146
8 p.m.	.324	.....	.....	.....	.....	.....	.....	100
10 p.m.	.221	.....	.....	.....	.....	.....	.....	53
12 midnight	.149	.....	.....	.....	.....	.....	.....	.....
2 a.m.	.102	.....	.....	.....	.....	.....	.....	54
4 a.m.	.098	.....	.....	.....	.....	.....	.....	54
6 a.m.	.127	.....	.....	.....	.....	.....	.....	25
Oct. 10, 1950 (Tuesday):								
7 a.m.	.208	532	208	39.1	67	64	95.5	71
8 a.m.	.391	1,116	552	49.5	475	386	81.3	661
9 a.m.	.407	1,142	778	68.0	531	417	78.5	621
10 a.m.	.375	1,178	906	77.0	408	340	88.3	596
11 a.m.	.391	1,378	864	62.7	628	534	85.0	801
12 noon	.359	1,246	.....	.....	481	413	85.7	641
1 p.m.	.359	1,312	944	71.8	472	377	79.9	686
2 p.m.	.375	1,804	1,140	63.2	565	489	86.5	936
3 p.m.	.316	1,200	748	62.3	431	376	87.2	586
4 p.m.	.287	1,300	820	63.0	393	362	92.0	661
5 p.m.	.287	968	590	60.9	306	236	77.2	391
6 p.m.	.272	854	538	63.0	310	258	83.1	461
7 p.m.	.301	974	604	62.0	347	280	80.7	516
8 p.m.	.237	992	506	51.0	432	341	79.0	666
9 p.m.	.233	944	498	52.9	437	351	80.3	596
10 p.m.	.220	946	474	50.1	362	286	78.8	531
11 p.m.	.195	808	564	69.8	247	179	72.5	396
12 midnight	.172	788	472	59.8	165	117	71.0	301
1 a.m.	.149	616	456	74.0	117	81	68.2	201
2 a.m.	.138	640	192	30.0	49	25	51.0	131
3 a.m.	.106	616	204	33.1	54	29	53.7	81
4 a.m.	.106	532	116	21.8	31	24	77.4	71
5 a.m.	.106	616	284	46.1	17	14	82.3	26
6 a.m.	.117	266	182	68.5	9	6	66.6	76
Averages	.260	945	550	58.8	306	248	81.0	446
Oct. 16, 1950 (Monday):								
7 a.m.	.220	440	154	35.0	63	40	63.5	131
8 a.m.	.407	1,532	948	61.9	1,070	805	75.3	756
9 a.m.	.440	1,604	1,072	66.9	567	431	76.0	771
10 a.m.	.458	1,716	1,216	71.0	804	610	76.0	841
11 a.m.	.458	2,032	1,300	64.0	972	672	69.0	1,131
12 noon	.391	2,178	1,481	68.2	1,522	1,222	80.4	1,131
1 p.m.	.330	1,918	1,385	72.3	1,038	858	82.8	1,041
2 p.m.	.345	1,294	891	68.9	564	468	83.0	671
3 p.m.	.330	1,482	974	65.6	666	558	83.8	811
4 p.m.	.272	1,359	912	67.1	484	450	93.0	701
5 p.m.	.259	1,256	876	69.8	448	413	92.3	611
6 p.m.	.246	920	556	60.5	312	.....	.....	381
7 p.m.	.259	878	508	57.2	463	386	83.3	601
8 p.m.	.272	995	704	70.7	501	426	85.0	346
9 p.m.	.220	1,028	736	71.6	429	376	87.7	306
10 p.m.	.195	772	452	58.5	308	267	86.7	466
11 p.m.	.184	672	404	60.1	376	328	87.2	631
12 midnight	.161	725	472	65.0	179	156	87.2	326
1 a.m.	.127	757	482	63.7	184	155	84.3	351
2 a.m.	.106	592	354	59.8	107	80	74.8	211
3 a.m.	.087	580	308	53.0	50	43	86.0	151
4 a.m.	.087	538	234	43.5	14	6	42.9	109
5 a.m.	.097	548	258	47.0	43	36	83.8	109
6 a.m.	.106	477	189	39.6	57	57	100.0	81
Averages	.251	1,096	703	64.1	468	385	82.3	529
May 28, 1951 (Monday):								
7 a.m.	.425	812	280	34.5	73	59	.....	64
8 a.m.	.660	1,004	544	54.1	333	298	77.8	104
9 a.m.	.750	1,107	723	65.4	492	372	75.6	189
10 a.m.	.850	1,532	812	53.0	590	440	74.6	304
11 a.m.	.850	1,660	1,108	66.7	690	508	73.6	434
12 noon	.740	1,584	1,016	64.0	818	698	85.3	434
1 p.m.	.740	1,466	1,092	74.5	422	336	79.5	374
2 p.m.	.750	1,476	842	57.1	626	514	82.1	434
3 p.m.	.690	1,550	1,006	64.9	664	564	85.1	654
4 p.m.	.650	924	636	68.8	398	338	85.0	384

TABLE 17.—*Hourly variations in raw-sewage characteristics*—Continued

Time	Flow (MGD)	Total solids (ppm)	Total volatile solids (ppm)	Percent volatile solids	Suspended solids (ppm)	Suspended volatile solids (ppm)	Percent suspended volatile solids	B.O.D. (ppm)
5 p.m.	.600	1,170	774	66.1	502	294	58.6	339
6 p.m.	.600	1,098	698	63.6	436	336	77.0	289
7 p.m.	.550	1,082	660	61.0	424	314	74.1	384
8 p.m.	.490	1,066	704	66.1	448	354	79.0	289
9 p.m.	.425	970	558	57.5	368	334	90.8	364
10 p.m.	.400	928	536	57.8	240	194	80.8	309
11 p.m.	.375	890	522	58.8	181	166	91.7	254
12 midnight	.325	782	398	50.9	226	137	60.6	199
1 a.m.	.300	920	420	45.7	159	105	66.0	169
2 a.m.	.250	964	460	47.7	121	68	56.2	114
3 a.m.	.250	516	200	38.8	51	.....	.....	99
4 a.m.	.240	412	188	45.6	20	.....	.....	89
5 a.m.	.225	600	212	35.3	40	37	92.5	104
6 a.m.	.250	570	162	28.4	46	.....	.....	84
Averages	.516	1,045	606	58.0	351	273	78.9	270
May 21, 1951 (Monday):								
7 a.m.	.450	502	134	26.8	38	31	81.5	58
8 a.m.	.725	1,106	666	60.3	460	347	75.5	264
9 a.m.	.800	1,344	828	61.6	740	548	74.1	424
10 a.m.	.855	954	722	75.8	580	430	74.1	414
11 a.m.	.855	1,366	816	59.8	506	352	69.5	624
12 noon	.750	1,452	924	63.5	670	514	76.6	694
1 p.m.	.720	1,368	904	66.0	530	434	81.9	724
2 p.m.	.750	1,396	972	69.6	466	374	80.1	854
3 p.m.	.725	1,322	957	72.4	569	461	81.0	684
4 p.m.	.640	1,032	904	87.5	288	270	93.8	544
5 p.m.	.625	840	576	68.6	226	200	88.5	363
6 p.m.	.600	649	383	59.0	414	350	84.5	524
7 p.m.	.575	911	703	77.1	238	222	93.2	372
8 p.m.	.500	1,388	1,440	.....	462	416	90.0	454
9 p.m.	.445	1,006	832	82.5	386	336	89.4	368
10 p.m.	.425	1,172	816	69.6	476	424	89.0	580
11 p.m.	.415	778	442	56.9	282	238	84.5	510
12 midnight	.350	838	528	63.0	170	143	84.1	345
1 a.m.	.285	482	187	38.8	15	.....	.....	145
2 a.m.	.240	512	212	41.4	31	19	61.3	140
3 a.m.	.225	484	172	35.6	14	.....	.....	151
4 a.m.	.225	516	298	57.8	25	.....	.....	155
5 a.m.	.225	526	224	42.5	20	14	70.0	165
6 a.m.	.250	514	166	32.3	38	31	81.5	161
Averages	.530	932	581	62.4	318	258	81.1	405

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